Some thoughts on CDF measurements and their significance - either in their own right or relative to LHC capabilities

Jimmy Proudfoot, Sept 9th, 2005

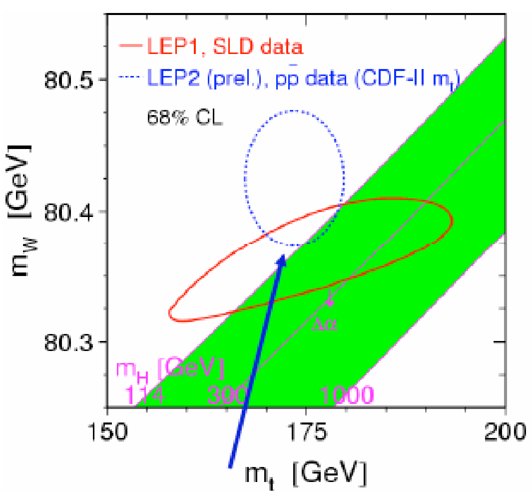
To make this more visual, when I was on shift last week I collected material from various presentations – one of the better sources was the Hadron Collider Physics meeting in Les Diableres (Henry make know of more since he was a particpant.)

The points I have below comprise:

- Top mass
- pdf's
- Z+jet rate and topology near the kinematic limit

Top Mass

Top Mass (from Eva's talk on the public web page)



For a fixed Higgs mass, EW radiative corrections imply:

Δm_{top} =1 GeV ⇒ Δm_W(mt)= 6MeV,

with Δm_W(theory)= 5MeV

Since the expected accuracy for the m_W is 15 MeV then a 1-2 GeV aim for Δm_{top} is desirable.

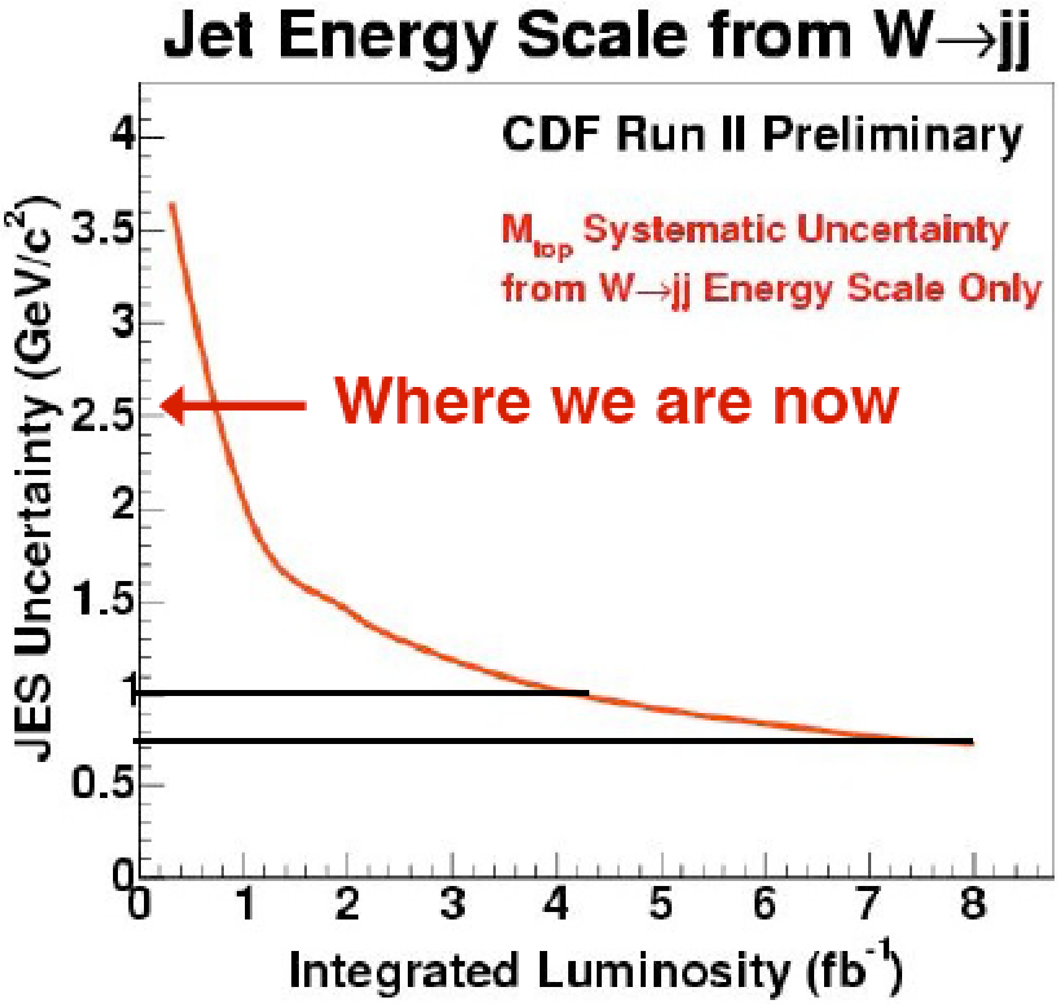
A key test, once we have a Higgs mass, is to look for consistency between the W, Top and Higgs mass.

Event selection (in particular the jet thresholds) at the LHC will be quite different from those at the TeVatron. **Therefore, although both will be using a constrained fit to the W mass, they are plausibly sensitive to different types of systematics**. For example at CDF, unlike the case at the LHC, there is little or no bias from angular resolution and jet separation – hence it is important to determine the accuracy of the W+jet kinematics in the Monte Carlo. Z+Jet in data provides a way to do this test (a lot of work has already been done on this by Henry and others.)

Another question is the precision with which we can measure W + b jets from QCD

I think that we can successfully argue that CDF will provide a competitive measurement of the top mass to that from the LHC, if we have 8 fb^{-1} of luminosity on tape – as indicated below.

Improvement with integrated luminosity



An OPTIMISTIC estimate for 8 fb-1
JES Uncertainty => 0.7 GeV
Background shape systematic will plausibly scale inversely with luminosity as for the JES. So =>0.3GeV
The statistical uncertainty => 0.5GeV
MC Statistics => 0.1
Assume we can improve our understanding of the method => 0.2
Leave everything else the same, then you estimate that the total uncertainty will be1.3 GeV.
This was even before I talked with Young-Kee and found out that out official projection for the uncertainty is 1.2GeV !

Can we reduce the systematic uncertainty from ISR and FSR?

In any event, this is quite competitive to the uncertainty on the top mass using the basic analysis at the LHC, which gives a total uncertainty of 1.3GeV

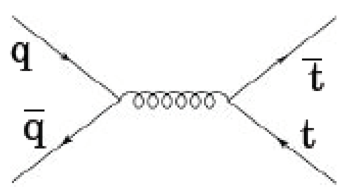
Systematic Uncertainties

CDF: From Tomura's talk at HCP2005

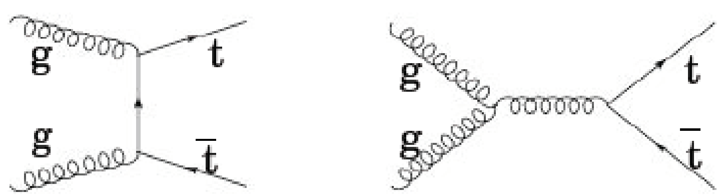
CDF Lepton+Jets Template

Source	Δm_t (GeV/c^2)
JES	2.5
b-jet modeling	0.6
ISR	0.4
FSR	0.6
PDFs	0.3
Generators	0.2
BG shape	1.1
b-tagging	0.1
MC statistics	0.3
Method	0.5
TOTAL	**3.0**

85%



15%



$$\sigma^{\text{theo}}(t\bar{t}) = 6.77 \pm 0.42 \text{ pb}$$

LHC: from talk of Lucotte at HCP2005

Top mass uncertainty

Main systematics :

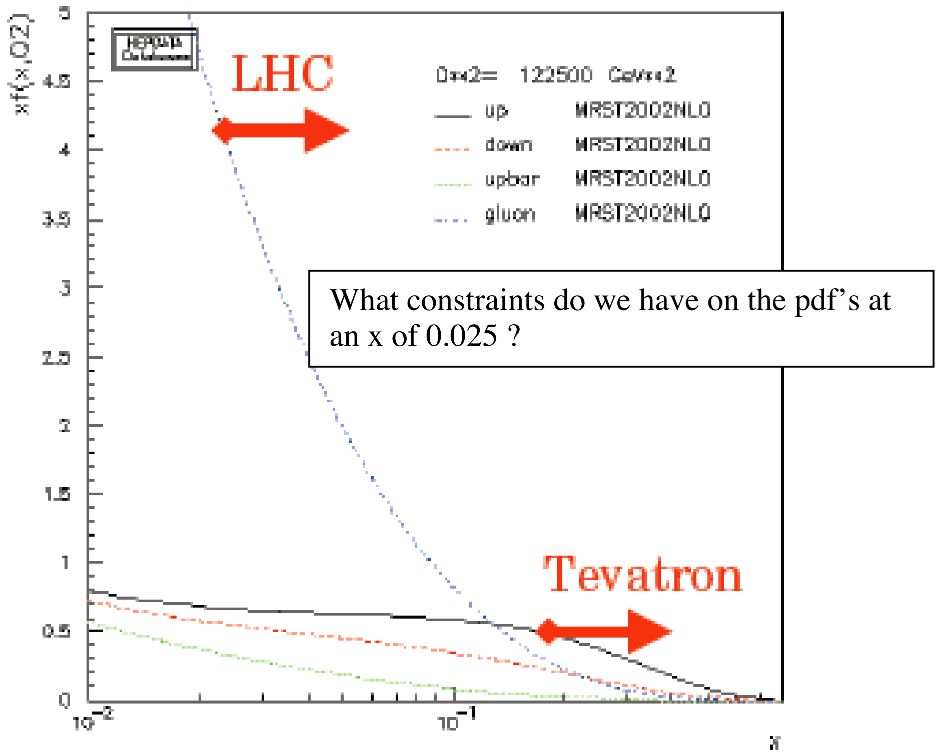
sources of uncertainty	$\delta m_t (GeV/c^2)$
light jets energy scale	0.2
b-jet energy scale	0.7
Initial State Radiation	0.1
Final State Radiation	1.0
b-quark fragmentation	0.1
Combinatorial backgd	0.1
Total SYSTEMATIC	1.3
Total STATISTICAL	0.07

Δm_t for a 1% miscalibration

1.0 -> 0.5 by chi-squared cut on fit.

Entire analysis relies crucially on the assumption that there is essentially no non-top background. I don't understand the comment in the talk about FSR being reduced by making a chi-squared cut

PDFs, Signal and Background to Top



From Busato's talk at the Hadron Collider Physics Workshop, 2005

Event yields @ 10 fb^{-1}

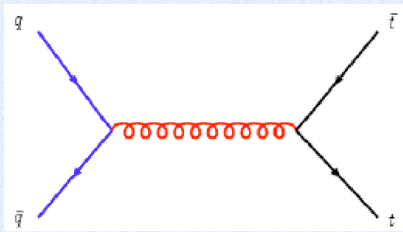
Processus	σ x BR (pb)	ε(%)	N_{events}
bb→lν+jets	2.2×10^6	3×10^{-8}	15
W+jets→ lν+ jets	7.8×10^3	2×10^{-4}	930
Z+jets →l^+l^-+jets	1.2×10^3	6×10^{-5}	150
WZ → lν + jets	3.4	1×10^{-2}	12
WW → lν + jets	17.1	7×10^{-3}	10
ZZ → l^+l^- + jets	9.2	5	5
Tt → (lν)b (jj)b	250	3.5%	87,000

Main background from wrong combinations in tt events

A. Lucotte / LPSC

FROM TEV TO LHC

Tevatron



85% of the total cross section

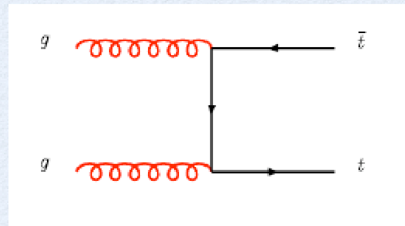
10 tt pairs per day

60% of the time there is extra radiation so that pt(tt)>15 GeV.

tt are produced closed to threshold, in a ${}^3S_1[8]$ state. Same spin directions. 100% correlated in the off-diagonal basis.

Worry because of the backgrounds: (W+jets, WQ+jets,WW+jets)

LHC



90% of the total cross section

1 tt pair per second

Almost 70% of the time there is extra radiation so that pt(tt)>30 GeV.

tt can be easily produced away from threshold. On threshold they are ${}^1S_0$ state, with opposite spin directions. No 100% correlation.

Worry because IT is a background!

- Experimental side: optimal situation!
  Tevatron: steady increase of luminosity+experience overcomes small rates and calls for sophisticated analysis.
  LHC: huge statistics→ top is day-1 physics with an amazing phenomenology.

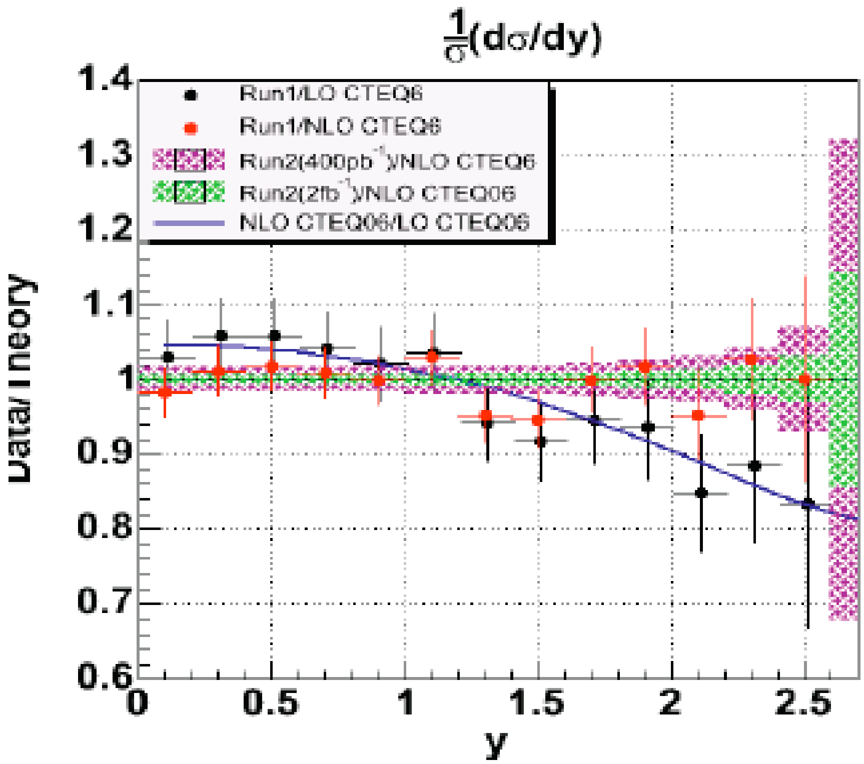
From Maltoni at HCP2005

Vector Boson Production and Tests of QCD

Z + Jets: a different type of constraint on parton distributions when you consider semi-inclusive final states.

Z+Jets at the LHC is a basic process to be understood as an element of the searchs – SUSY and Higgs. If we are to understand it, then we need to have sensitive tests at lower energy, where the effects of new processes are not important.

Since VB + Jet is the principal background to top, we need to be certain that we understand the rate, energy spectrum and correlation between jets in this process



Study Z + jet production as a function of Z rapidity – possible approach to become more sensitive to pdf's and differences between LO, NLO and NNLO. Hard to quantify the luminosity required for this study, since it hasn't been attempted with the present data – plausibly if the y sensitivity becomes observable at 0.4fb-1, then the semi-inclusive sensitivity will require at least 5 times as much (0-jet/1-jet rate)